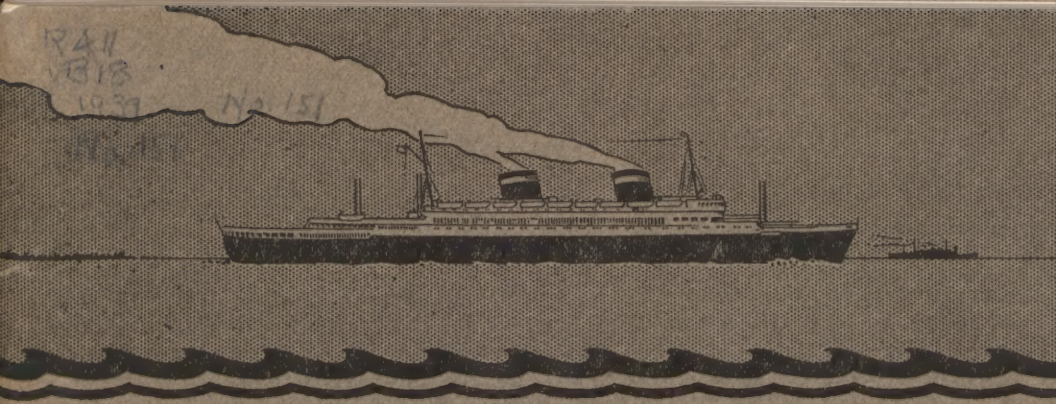

RATPROOFING OF NEW SHIPS

UNITED STATES
PUBLIC HEALTH SERVICE

UNITED STATES TREASURY DEPARTMENT

PUBLIC HEALTH SERVICE

THOMAS PARRAN, *Surgeon General*

THE RATPROOFING OF NEW SHIPS

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It contains (1) current information regarding the prevalence and geographic distribution of communicable diseases in the United States, insofar as data are obtainable, and of cholera, plague, smallpox, typhus fever, yellow fever, and other important communicable diseases throughout the world; (2) articles relating to the cause, prevention, and control of disease; (3) other pertinent information regarding sanitation and the conservation of the public health.

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CONTENTS

THE RATPROOFING OF NEW SHIPS

Introduction

The maritime world recognizes that rat life aboard ship is a menace to health and an economic burden. For these controlling reasons it is incumbent upon naval architects and shipbuilders to provide ships of ratproof design and construction.

The entire theory of simplified ship ratproofing is based upon the elimination of all enclosed spaces which bear no functional relationship to the ship's operation. Since closed spaces are always subject to boundary damage which will permit rats to enter and nest, they are obviously best treated by complete elimination, which not only permanently solves the ratproofing problem but also affords access to the ship's structure to facilitate cleaning and painting. Clearly the best time for eliminating these spaces is when the plans are being drawn, as it is far simpler as well as less expensive to correct the plans of a projected ship rather than to make changes on the completed or partially completed vessel. In the majority of cases the principal problem involved is one of correctly placing fixtures such as pipes, ventilating ducts, cables, and the like, or the proper placing of lightening holes in the structure itself. When this problem is properly solved by applying ratproofing principles to a ship's design, the vessel will not only be free from structural rat harborage but also will be lighter and less expensive to build and maintain.

It is clearly seen that the success of constructing a ratproof ship at low costs rests largely in the hands of the designing staff; hence this publication has been prepared principally for those who are interested in the design and construction of ships. It is intended to bring to the reader's attention only the salient features of ship ratproofing. The plates at the end of this publication are in most cases simple diagrams prepared with the thought in mind of clarifying a given point, and for this reason they are submitted in their most elementary form, all nonessential details being omitted to avoid confusion.

The Ship Rat

Designers and constructors may solve the various problems of ratproofing more effectively if they are acquainted with the habits and activities of the rat.

The rats usually found on ships are the black rat (*Rattus rattus*) and the gray or "roof" rat (*Rattus alexandrinus*); only occasionally is the brown, or "Norway," rat (*Rattus norvegicus*) found. The black and gray rats are variants of the same species. They are smaller, more slenderly built, and have larger ears than the brown rat. Their tails are longer than the combined length of head and body, while the tail of the brown rat is shorter.

HABITS OF RATS

The primary interest of the rat is to seek shelter near an adequate supply of food and water. Certain parts of the ship are preferred by rats for locating their homes, and the size of a rat colony bears a relationship to the amount of harborage available.

Extensive observations made of ship rats indicate that the female produces three to six litters annually, each litter consisting of an average of seven rats. Rat colonies on shipboard, under favorable conditions, may increase at the rate of approximately 3 percent per day.

On shore, rats are active chiefly at night; but aboard ship, particularly in dark holds, they are more or less continually on the move. The number of rats aboard can be accurately estimated from the rat droppings, runways, gnawing, and various other signs; rats can be traced to their harborage by following the dirty smudges left when their bodies rub on the surface over which they travel. Rats never gnaw on a flat surface but always on an edge or corner; they can jump approximately 3 feet, and they are such excellent climbers that their agility must be actually observed to be realized.

SOURCE OF RATS FOUND ON SHIPS

Rats originally come aboard ship during construction, existing on scraps from workmen's lunches. On ships in service they come aboard either in cargo or in ship's stores, or they crawl up the gang planks and ship's lines. Rat guards are not effective unless they are properly made, intelligently fitted, and very carefully maintained. A new ship should be carefully inspected for rats before leaving the builder's yard.

Rat Suppressive Measures

TRAPPING—POISONING

If undertaken on a shipwide scale by trained, industrious trappers, trapping is an effective means of reducing a ship's rat population. Success in trapping depends largely upon the nonavailability of food other than that displayed in traps.

Poisoning is not recommended as a rat-suppressive measure, because the results are indeterminate and rats frequently die in closed spaces. Moreover, rat poisons are dangerous to the administrator if improperly handled.

FUMIGATION

Fumigation with hydrocyanic acid gas is the most effective means of promptly reducing a large rat population aboard ship. The results, however, are only temporary, as the ship may soon become reinfested with rats. In the long run, ratproofing is the more economical, as the cost of repeated fumigations will ultimately far exceed the cost of ratproofing a vessel.

CLEANLINESS

Freedom from rats depends in a large measure upon proper maintenance and cleanliness of the vessel itself. A ship must be systematically cleaned at frequent periods, and during this procedure all movable stores and equipment should be repiled. Each time a hold is emptied, the dunnage should be stacked and the hold swept clean before the dunnage is again laid. Painting and artificial lighting promote cleanliness.

HARBORAGE

Harborage is divided into three types or classes—structural, incidental, and temporary.

Structural harborage is that type which is integral with the ship's structure. Incidental harborage is that type located in or around equipment placed within a ship. Temporary harborage is that type existing in movable supplies, stores, dunnage, machinery spare parts, and the like. In other terms, structural harborage results from faulty design and construction and is built into the ship; incidental harborage is placed aboard when the ship is fitted out; and temporary harborage results from the manner in which a ship is operated.

RATPROOFING

Ratproofing includes the abolition of harboring and nesting places, the separation of the rat from a food supply, and the limitation of rat operations between compartments. A ratproof ship is one on which it is so difficult for rats to live and multiply that they leave or ultimately suffer extinction.

A ship designed and constructed in accordance with the principles of ratproofing usually weighs less and costs less than one on which these principles are not observed. Ratproof ships are more easily cleaned, maintained, and fumigated. Since the principles of rat-

proofing and fireproofing are largely parallel, it follows that a ratproofed ship is also fire resisting. It is a fortunate circumstance that both ratproofing and fireproofing have been materially advanced in recent years by the virtual elimination of wood in ship construction.

Through international agreement, every vessel engaged in foreign commerce is required to carry an acceptable certificate indicating freedom from rats or be subject to deratization if inquiry and inspection indicate that such measure is necessary. The certificate attests either that the ship has been recently fumigated (deratization certificate) or that inspection disclosed no signs of rat infestation (exemption certificate). Ships constructed in accord with ratproofing principles are readily maintained free from rats and in consequence are generally accorded exemption certificates, avoiding the many times more costly fumigations as well as the attendant delays.

Ship Ratproofing

GENERAL

Design and Construction.

Ratproofing may be accomplished in two ways—by protection of or by elimination of partially or totally enclosed spaces. Protective methods apply generally to the ratproofing of existing ships which have numerous spaces available for rat harborage and which can be protected from invasion only by making them ratproof. This method is costly, adds additional weight to the ship, and is a constant source of expense for repairs. Workmen are too prone to open up enclosed spaces, effect repairs to pipes, cables, etc., then imperfectly replace the original covering, with the result that the formerly enclosed space is immediately made available to rats for harborage purposes. Protective methods should be used on new construction only as a last resort, provided it is impossible to eliminate or open up the space in question; this is generally an indication of poor design or faulty construction.

Ratproofing by elimination of enclosed spaces is applicable in the designing and construction of new ships. It is by far the most scientific and satisfactory method as it results in lighter weight, reduced construction costs, improved workmanship, easier maintenance, and does not require continued attention and frequent inspection. In preparing the design of a ship ratproofed by this method, no allowance for weight of ratproofing is necessary. Furthermore, if the ratproofing is properly carried out by the process of elimination and correctly locating all appurtenances, no additional cost for ratproofing need be included in the bid cost of a ship.

Since the majority of inaccessible or semienclosed spaces can be eliminated or opened up by proper attention to the design of the vessel, and by proper attention being paid to the location of ventilating ducts, pipes, cables, furniture, fixtures, and similar features, the logical place for a ship to be made ratproof is in the designing room. Too much stress cannot be made of the point that it is of vital importance to the shipyard, in maintaining reduced construction costs, to have the designing staff well versed in the subject of ratproofing. Errors or poor judgment on the part of the designers can be a source of considerable unnecessary expense. Countless times a nonratproof space may be made ratproof by relocating a pipe or vent duct 1 or 2 inches from its original location. All such work should be performed without expense on the blueprints in so far as possible, rather than at considerable expense on the partially completed ship. However, many details of construction do not show on the detail plans, and for this reason an available trained, qualified construction man is a great asset to the builder; by offering timely suggestions, errors in construction can be anticipated and corrected before they are made, thus economizing on man-hours, weight, and time.

A safe guiding rule in correct ratproofing of a ship is to *eliminate all enclosed spaces or any which are not open to visual inspection; entirely surround any mass storage of supplies with a ratproof bulkhead or expanded metal partition; use only ratproof materials and install them in a ratproof manner.*

It is impossible to cover every detail of construction, but discussion of the more common features will serve to illustrate the whole principle of ratproofing vessels, as well as many of its specific affiliations.

Longitudinal hull frames or horizontal stiffeners should always be placed toe down, thus eliminating the partially hidden area which is formed behind the beam flange when it is placed toe up.

Cargo battens running parallel to hull longitudinals or horizontal brackets should be placed several inches above these structural members so that no partially hidden pocket is formed behind the batten. (See plate 1.)

Sparring to protect a tank bulkhead should be arranged with vertical bearers to carry horizontal battens, thus eliminating horizontal shelves for nesting on top of the partially hidden bearers. (See plate 3.)

With reference to *expanded metal partitions* surrounding storerooms, the designer should indicate on the plans that the clearance between the frame which carries the expanded metal and the aperture in which the metal screen fits should not exceed three-eighths inch. The foremen who construct such expanded metal screens or partitions will readily realize that the construction of a screen with three-

eighths inch boundary clearance is as simple as constructing one with three-fourths inch boundary clearance. However, the difference is that the former is ratproof and the latter is not. It has further been noted that when the workmen work to this reduced clearance, more care is exercised on their part and they usually execute a superior piece of work. To maintain the integrity of boundary bulkheads surrounding storerooms it is of vital importance that all lightening holes and erection holes in the ship structure in way of such bulkheads be closed off either with wire mesh or steel sheet discs; similarly, pipes or cables passing through these partitions must be fitted with collars in way of partitions if the clearance between a hole and pipe exceeds one-half inch. Special attention must be given to doors entering storerooms to insure the fact that the top, bottom, and side clearances of the doors do not exceed three-eighths inch. Proper construction of these partitions is indicated on plate 7.

In the case of *electric cables*, it is advisable, where headroom permits, to suspend cables in vertical racks, thus making the individual cables more accessible for inspection or replacement and affording complete accessibility of the deckhead above the cables for cleaning and painting. In instances where it is impossible to adopt this method of erection, it is necessary to run the cables in horizontal racks. In this latter case it is required that the various racks have a maximum separation and that the upper row of cables be sufficiently removed from the deckhead to permit inspection of the top surface of the cables for possible presence of rat nests and to permit access to the deckhead for cleaning and painting. The proper and improper methods of erecting cables are indicated on plates 11 and 12. Where cables are run in groups parallel to structural members at the ship's side, the cables should be placed sufficiently above structural members longitudinally to permit complete inspection of the structural surfaces and top surfaces of cable groups and to avoid forming a pocket behind the cables where rats could nest. It is evident from this that ratproof construction with reference to cables may be realized merely by their proper placement. In cases where it is necessary to run cables through a structural beam with a horizontal opening or lightening hole for this purpose, the group of cables so run should be twisted 90° on each side of the beam so that they can be run otherwise in vertical racks.

In laying out *pipe lines* the designer and the construction men should insure the fact that pipes are run with at least a 2-inch clearance between the lagging and parallel partitions or bulkheads. Too often the pipes are laid out correctly spaced, but the draftsman overlooks the fact that lagging to be subsequently fitted reduces the clearance between pipes to the extent, in some cases, of leaving no

clearance at all. A maximum spacing between pipes is essential to permit inspection of the deckhead above and to insure the fact that the pipes are sufficiently separated to prevent rats from building nests on the upper surfaces. If it is necessary to run pipe lines parallel to and touching each other, it is essential that the entire group be placed sufficiently low to provide visual inspection of their top surfaces; this condition, however, seldom obtains. In cases where a pipe is run parallel to a ventilating duct and is separated from it by a structural longitudinal or transverse, it is noted in many cases that the structural member is provided with lightening holes. These holes are of vital importance in providing opportunity to inspect the upper surface of the ventilating duct, as shown on plate 16. If the above-mentioned pipe is placed sufficiently low to permit this inspection, the area over the vent duct will be ratproof; but if by improper placement the pipe fitter erects the pipe directly in front of the row of lightening holes, the area over the ventilating duct is not ratproof and considerable expenditure will be required either to lower the pipe line or thoroughly to enclose the space around the ventilating duct, either process being of the type to be avoided.

In numerous instances where *ventilating ducts* are run parallel with structural members or bulkheads, they should be placed tight up against the deckhead plate above or sufficiently low to permit inspection of their upper surface. If the duct cannot be lowered to this extent, the construction will still be ratproof if properly sized and spaced lightening holes are cut in the structural members running parallel with the duct. The size and spacing of lightening holes must be determined by one well versed in the strength of the ship structure in order that the section modulus of the structural members will not be impaired.

In general, the clearance between the side of a vent duct and any parallel structural member should not be less than 9 inches. This limit may be reduced in cases where inspection of top surface of the duct is possible through lightening holes cut in the vertical webs of adjacent parallel structural members.

On plate 16 the upper right sketch of disapproved installations of vent ducts can be made ratproof without lightening holes provided the top of vent-duct lagging is at least 5 inches below the deckhead plate and the sides of the duct are at least 9 inches away from the flange edge of the parallel deck beam. The 5 inches represents an average distance of the eye below the top of the head and the 9 inches permits the human head to be inserted and turned to view the duct surface, thus allowing complete visual inspection.

The type of vent duct having a circular top is always ratproof, as rats cannot nest on its upper surface. The designer, however,

is cautioned that such a duct will form potential harborage space if placed against any parallel structural member; hence ducts of this type must be placed at least 1 inch, or preferably more, away from any structural member running in a parallel direction. (Note the bottom sketch on plate 15.)

When vent-duct lay-out plans are being prepared, the draftsman must keep in mind that all spacings just given are to the outside of any lagging which may be used on the ducts. Furthermore, the diagrams shown on plate 16 indicate the outside measurements of lagging rather than the duct itself. Due allowance must, therefore, be made in all cases where lagging is used. *Terminals* on ventilating ducts must all be provided with ratproof screens, irrespective of whether the duct is for supply or exhaust and irrespective of whether an insect screen (either copper or corrosion-resisting steel) is used. In the latter case, both the insect and ratproof screen are carried on the same frame. To prevent removal of these screens they should be secured to the terminals with fast pin hinges located at the bottom of the screen, the theory being that the fast pin hinge prevents removal of the screens by the crew; and since it is hinged at the bottom, an open screen will be in a position to cause substantial head bruises, thus providing some degree of assurance that it will be kept closed.

In ships where *terminal heaters* are installed for heating the ventilating air, such heaters afford comfortable harborage easily accessible to rats. The logical method of design to follow is to block off entirely the harborage in front of and behind the heating core by placing a ratproof screen at the front of the heater which blocks off all passages to the back of the heater, as indicated on plate 17. It is obvious that this condition of design is most easily met by the designers of the various types of terminal heaters, so that when this equipment is delivered to the shipyard it should be ratproof and ready for installation.

In the case of small-sized *life-belt boxes* suspended from the deckhead, it is important that the upper edge of the box be located not over three-eighths inch from the deck plate above. This prevents rat ingress and yet provides ample ventilation. The clips securing such boxes in position should also extend to within three-eighths inch of the deck plate. Holes in the boxes made for passage of cables or pipes should be of such diameter that the cable or pipe in question fits snugly therein; if not, a close-fitting collar must be placed around such pipes or cables where they enter the box. (See plate 12.) Boxes should be placed well away from any structural member, thus avoiding the formation of a pocket between deck beams and box sides. Proper placement of the box makes further ratproofing entirely unnecessary.

With reference to *kick plates* or *pipe covers* protecting pipes in way of passage doors, around the pilot house walls, and similar places, it is essential that such plates or covers extend down from the top only sufficiently to protect the pipes in question. These plates should not be curved back on the bottom for the purpose of being secured, as such bottom curve forms a shelf for rat nesting. If support at the bottom is desired, it is advisable to fit a U-strap at each end of the plate and extend the kick plate from the top about half way down the U-strap; in this way the plate is thoroughly secured, yet no harborage is formed and lighter construction is the result. This is illustrated on plate 14.

It has been found that rats will nest in the bottom machinery compartment of *electric refrigerators* or *drinking-water coolers*. It is, therefore, necessary completely to screen in the machinery compartment with ratproof screen or expanded metal, and where holes are cut in the mesh for the passage of water pipes or electric cables, such pipes or cables must fit snugly in these holes; otherwise metal collars are indicated. Most manufacturers build their equipment in this manner. In addition, the front door to the machinery compartment must be tight fitting on all sides.

An ideal *refrigerating compartment* such as is standard practice construction on ships of the United States Navy is illustrated on plates 24 and 25. Prior to the practice of constructing inner and outer walls of refrigerator spaces with metal, the insulation space proved to be one of the most vulnerable spaces aboard ship for rat harborage. The use of wood anywhere in the construction of these spaces is to be strongly discouraged. It will be noted from these plates that the entire refrigerator space is of metal construction, with all joints tight, thus preventing gnawing by rats. In this as well as in many other respects the merchant marine can follow no better example than that set forth by the methods of construction which are standard practice with the Navy.

It is essential to avoid any wide flat surfaces above the level of the eye. An excellent illustration of this point is shown in the photograph of a *cargo port* (plate 27). It will be noted that the shelf stiffener above the port, due to its height above deck, forms a passably comfortable location for rat harborage in the outer corners. In the case illustrated it was necessary to screen off the shelf to prevent its use by rodents. The method used to avoid this type of construction is evident; the required compensation for strength in the hull structure due to the aperture cut for the cargo port can be obtained by placing sufficient doubling on the hull plates in way of the port. Such doubling plates furnish the required strength of structure but do not form a shelf where rats may nest; hence no ratproofing is required since the space has been eliminated.

Fireproofing and Ratproofing.

The problems of rat control and fire control aboard ship are so similar that they are almost identical; conditions creating a fire hazard are conducive to the existence of permanent rat colonies. The corrective measures applied to realize effective protection from fire or rats are, therefore, fundamentally similar. It may be noted that as early as 1926 the Public Health Service advocated types of ship construction as being ratproof which are now recommended and used for fireproof construction. These recommendations consist chiefly of designing each compartment to be an isolated rat-tight space, requiring the elimination or effective ratproof closing of structural openings, and avoiding dead spaces in the ship's structure or, where they cannot be avoided, making them inaccessible to rats.

Materials.

Fireproof bulkheads of class A–1 and class A and fireproof doors of class A–1 and class A material are excellent from the standpoint of ratproofing; however, some of the materials recommended for wall panels are not of ratproof character but can be made so by installing the panels in metal assembly frames which will protect all exposed edges from gnawing of rats.

The use of wood anywhere in the ship is to be heartily discouraged. For some uses it may be less expensive in the beginning, but it is very expensive in the long run. As ships are now constructed, the requirement for wood is practically nil.

Perforated sheet metal or expanded metal should not be thinner than No. 18 U. S. gage (0.05 inch), and the greatest dimension of perforations should not exceed one-half inch.

Sheet metal for flashing, patching, and for collars around pipes, cables, or structural members should not be thinner than No. 18 U. S. gage (0.05 inch), secured with machine screws or bolts. Thicker metal should be used when it is subject to damage or corrosion.

Sheet aluminum for flashing, collars, and similar uses should not be softer than three-quarters hard.

Wire screens should be made of wire not smaller than No. 14 A. W. G. (0.064 inch), and the greatest dimensions of mesh should not exceed one-half inch. Screen materials should be secured in substantial metal frames, the frames to be secured to surrounding structure with machine screws or bolts. Where screens are carried in wooden frames (not recommended), the wire mesh should extend to the outer edge of the frame. It should be pointed out that copper or corrosion-resisting steel insect screens are not proof against rats; if they are broken, the openings made give free access to rats for entering the ventilating system. If such screens are used, they

should be provided in conjunction with ratproof screens of heavy mesh, both being secured to the same frame.

All corrodible ratproof material should be galvanized or otherwise suitably protected against corrosion.

Materials used for ratproofing must be substantial, closely fitted, and thoroughly fastened with machine screws or bolts and *must be so maintained.*

Any parallel-sided opening such as that around doors, around expanded metal bulkheads, width of louvers, and the like, should not exceed three-eighths of an inch in its smallest dimension.

Holes for construction purposes, for ventilation, or for any other purpose are not ratproof if they exceed one-half inch in diameter.

General Notes.

Design each *compartment* or group of compartments so as to form an isolated ratproof space; this includes the effective closing of all structural openings between such compartments.

Avoid *dead or inaccessible spaces* in the ship's structure; where they cannot be avoided, make them inaccessible to rats.

Avoid carrying *stores* in the forepeak and aft peak tanks. If peaks are used for stores, install facilities for open and orderly stowage.

Close with sheet metal or wire mesh all *unavoidable openings* for pipe lines, cables, conduits, drains, beams, stringers, etc., where they pass from one ratproof compartment to another. Close openings in structural members where such openings give access to a partially or wholly enclosed space. Close off or open up concealed recesses formed at intersection of girders or other structural parts; this includes spaces above side ports, spaces at base or head of built-up pillars, wide girders around cargo hatchway, and similar spaces.

Bulkheads or partitions with ventilating openings at the top should have these openings closed by wire mesh or expanded metal if they form the boundary of a ratproof compartment.

Shaftways for elevators or dumb-waiters should be of tight, well-fitted construction with closely fitted doors. Any openings into shaftways or *cable alleys* should be protected with expanded or perforated metal.

Service doors in way of watertight doors should be ratproof and of metal construction; if located at boundary of a ratproof compartment, they should be fitted with effective closing springs.

Stovepipes or other pipes passing through a weather deck must be fitted with metal collars at that deck.

Pipes passing through wooden bulkheads or partitions should be fitted with close-fitting metal collars. If passing through steel bulk-

heads or partitions no collars are required, provided the pipe holes in such bulkheads are sufficiently small to prevent rats from squeezing through between the pipe and the bulkhead. Where insulation terminates on each side of bulkhead, place collar around pipe before applying insulation. Where insulation is one-half inch or less thick, it may be continuous through bulkhead with collar fitted outside of insulation. Where insulation is over one-half inch thick and it is to run continuous through a bulkhead, fit a sheet-metal sleeve 24 inches long over the insulation, centered at the bulkhead, and then fit the customary collar over the sleeve. (See plate 10.)

Collars on pipes passing through wooden bulkheads or partitions must be of such diameter as to extend 3 inches outside the outer surface of pipe insulation.

Furniture and fixtures should be of steel, set on legs 10 to 12 inches off the deck, and fitted snugly against the partition with no space between partition and furniture, or furniture must be set well away from bulkhead to permit inspection of the space behind. Furniture shall not have any false bottom and shall have no enclosed spaces in framework suitable for rat harborage. (See plates 31 and 32.)

Cofferdams at base of bulkheads must be of ratproof design (plate 2).

Battens on sparred bulkheads or at ship's side must be installed so as to form no harborage over brackets between bulkheads and longitudinal stringers or no harborage over horizontal structural members (plate 1).

Omit in so far as possible any *sheathing in way of deckheads* and hull sides. If insulation is used at ship's side, it should be securely encased in close-fitting lightweight metal sheets.

Troughs for *indirect lighting* of public spaces should be of metal construction, with openings at ends closed off to prevent invasion of space beneath.

DETAILS

1. *Ceiling over tank top and bilges.*—Eliminate ceiling and increase tank top thickness as required by classification society. Carry tank top horizontally out to ship's side as shown on plate 22.

2. *Tank top pad under hatchway.*—Eliminate pad entirely. Half-round steel bars may be spot welded to tank top, bars to be laid radially from hatch location to side and corners of hold to facilitate dragging cargo along tank top to hatchway. If pad is used, make it solid by laying successive layers of planks upon each other with no separators or bearers between, the lowest layer to be laid in tar and the upper layers nailed to it. Pad edges should butt against a steel bar for protection. The pad should be 2 feet wider and 2 feet longer than hatchway opening.

3. *Spaces between hull frames at side in lower hold.*—Extend steel tank top to ship's side with no bilge cover. (See plate 22.)

4. *Sheathing under deck heads in holds.*—Eliminate entirely or make of metal.

5. *Wooden bulkheads.*—Eliminate all wooden bulkheads or wooden sheathing. If necessary to protect cargo from an oiltight bulkhead, use open sparring as in plates 2 and 3.

6. *Cargo battens.*—Place battens well above parallel structural members such as hull horizontals, horizontal brackets, horizontal stiffeners, etc., so top surfaces of such members are open to visual inspection (plate 1). Where sparring is fitted over a tank bulkhead, arrange the battens horizontally to be carried on vertical bearers; thus bearers do not form hidden ledges (plates 2 and 3).

7. *Ballast stowage.*—House ballast in steel containers; pour concrete in and around ballast, then fill concrete flush with top of container and cover with steel plate. Container may be permanently secured to ship's structure.

8. *Air-cooled or insulated cargo holds.*—Secure sheathing of steel sheets tightly with machine screws or welding. Eliminate deck gratings. Deck may be covered with tile if desired, but preferably should be bare (plate 22).

9. *Pillar foundations.*—Design open-type foundation with no enclosed space (plate 6).

10. *Hatchway coaming girders.*—Design girders with a minimum of horizontal flange. If flange must be wide and is high above line of vision, spot weld a screen of expanded metal over the horizontal flange placed at such an angle that rats will not nest thereon (plates 6 and 22).

11. *Forepeak stowage.*—Construct open-type steel shelves at least 10 inches off the deck and away from bulkheads for stowage of stores. Use steel bins of the ash barrel type having tight fitting metal covers. Make boundary of storeroom ratproof (plate 24).

12. *Forepeak and aft peak hatches.*—Construct entirely of steel and fit in a rat-tight manner. If hatch is to remain open fit a ratproof metal screen inside the coaming.

13. *Engineers' storerooms.*—Construct lockers of steel and avoid locating them in dark or isolated places. Make racks of shelves on open, steel framework locating them well away from any partition and elevated 10 to 12 inches above deck on legs. Do not back stowage bins up against a bulkhead having horizontal stiffeners or brackets which can be used for rat nesting (plate 25).

14. *Lockers.*—Construct of steel not over 5 feet high with top sloping toward front. If more height is required build up to fit tightly against deckhead. Avoid wide shelves. Locker should stand on legs 10 to 12 inches high. The use of a false bottom is to be avoided. Screen off openings leading into enclosures. The bottom shelf must fit tightly if the locker stands on legs (plate 23). Built-in lockers must have no openings into the deckhead.

15. *Shaft alley.*—Paint walls white and furnish good illumination throughout. Supplies if stored here must be kept in ratproof steel containers. Make foundations for shaft bearings of open type, structural steel, or if cast type is used cover lightening holes with expanded metal firmly secured with screws.

16. *Shaft alley escape.*—Make ratproof screen to fit under grating at top of escape trunk. Eliminate all horizontal ledges or stiffeners where rats could nest. This space is seldom used or inspected, hence is vulnerable if unprotected.

17. *Mail and baggage room.*—Design boundary bulkheads entirely of metal and ratproof. Omit all gratings. Construct pipe casings of steel with open type design and make shelves or racks of open design using structural steel (plate 23).

192669°—39——3

18. *Temporary stowage.*—Where temporary stowage of bedding, life belts, or any other surplus supplies is required, it must be ratproof. If crates are used they must be screened inside with wire mesh. Crate lids must be tight fitting and crate bottoms must set flush on deck. Temporary enclosures for stowage of bedding, etc., must be formed by tight fitting, temporary metal bulkheads.

19. *Refrigerated spaces.*—Design outer and inner partitions of steel with collars or stuffing boxes for all pipes or cables passing through the space which is filled with insulation. Fit metal partitions tightly around all structural members and secure partition plates with machine screws or welding (plates 24 and 25).

20. *Storerooms for provisions.*—Design lower half of partitions and doors of solid plate if weight is allowable, otherwise make entirely of ratproof expanded metal. All edges of partitions must fit snugly. Pipes or cables passing through partition must be collared. Eliminate gratings or hollow flooring. Store food in tight steel bins or garbage can type bins. Make shelves on structural steel, open-type framework (plate 25).

21. *Potato storage.*—Construct potato bins of ratproof metal with self-closing doors and catches. Place bins or lockers directly on deck or other solid base or elevate them on legs 10 to 12 inches above deck. Use only a ratproof grating on the locker bottom or preferably no grating at all (plate 26).

22. *Pipe casings—kick plates.*—Use only open, steel, skeleton-type construction (plate 9). Where pipes are laid on tank top and must be protected, make protecting shields of steel in sections with all joints closely fitted. Install pipe collars where pipes enter this casing. Where kick plates are fitted over pipes in way of doors or ladders, secure plate on top edge leaving bottom entirely open. Similar construction is used for ornamental covers to heating pipes (plate 14).

23. *Telegraph cable casing.*—Construct of sheet steel, making all joints tight and fitting collars around cables where they enter the casing. Place casing either hard up against deck or sufficiently low to permit visual inspection of top of casing. Casing must be four-sided to form a closed box, all edges being tightly joined.

24. *Electric cables.*—Install openly in vertical rows suspended on straps. If in horizontal rows, place so the top surface of each row can be visually inspected. Place well away from structural members running in a parallel direction (plates 11 and 12).

25. *Galley boundary.*—Eliminate sheathing at deckhead and hull sides, installing insulation on top side of deck above galley. Avoid constructing any enclosed spaces. Make boundary bulkhead or partitions entirely ratproof (plates 7, 13, and 26).

26. *Galley fixtures.*—Construct fixtures of metal and set them on legs 10 to 12 inches above deck or set them in solid concrete or tile foundation. Place fixtures either hard against bulkhead with no space between or place them well away from bulkhead. Close off all openings into galley fixtures. Avoid false bottoms in lockers. Avoid placing fixtures against horizontal stiffeners on bulkheads. If horizontal structural members pass through galley dressers or other fixtures the point of entry into such fixture must be made ratproof (plate 27).

27. *Galley refrigerators.*—Preferably use all metal construction, setting the refrigerator flush on deck on a concrete or tile base and building up the top to fit tightly to deckhead. As an alternate the top of the refrigerator may be sloping but in no case should it be open and flat.

28. *Stewards' lockers.*—Construct boundary partitions of steel and fit metal collars around pipes, cables, or vent ducts entering such compartments.

29. *Steps.*—Eliminate all enclosures under steps (plate 28).

30. *Wardrobes and settees.*—Wardrobes and settees should be open-type, steel construction, these fixtures being placed hard against the bulkhead with no intervening space between, or well away from the bulkhead. Construct wardrobes to extend up to deckhead or make the top sloping to the front. False bottoms or any enclosures in wardrobes are to be avoided. Metal settees must be designed to permit complete visual inspection in the open spaces beneath and behind them (plates 23, 29, and 31).

31. *Lavatories.*—Use only open plumbing. Any lockers or medicine cabinets must be of ratproof metal installed in a ratproof manner.

32. *Toilets and baths.*—Partitions must be of steel. All pipes, cables, vent ducts, etc., passing into or through this compartment will be fitted with metal collars. All plumbing must be open. Vent openings must be screened.

33. *Lockers under berths.*—Eliminate such lockers. If required, both the berth and the locker must be of ratproof metal, the entire unit preferably carried on legs 10 to 12 inches above deck (plate 31).

34. *Radiator and heat-pipe covers.*—Covers should be of metal and may contain a decorative design. They should be entirely open at bottom and ends (plate 14).

35. *Window casings.*—Casings should be entirely of ratproof metal (not lead) closely fitted. Do not allow room between glass and casing for rat to enter. Windows must drop entirely to the bottom of the watertight pocket when in the open position, thus preventing nesting in such an inaccessible space. If when windows are open they rest within the watertight pocket and do not travel to the bottom thereof, an excellent harborage is formed below the level of the clips over the bottom of the pocket.

36. *Side ports.*—Construct with doubling placed on hull sides thus eliminating the space over the port shown in plate 27.

37. *Ventilating ducts.*—Protect all openings into the vent system with ratproof mesh irrespective of whether insect screen is used. Allow no space on top of ducts which cannot be visibly inspected or place ducts tight against deckhead plates with no intervening space. Construct duct so that a deck plate or a deck beam and plate form one or two sides of the duct or use duct of semicircular cross section hung in straps welded to deck. Keep vent ducts well removed from structural members running in a parallel direction (plates 15, 16, and 17).

38. *Ventilators to deck house and hold.*—Ventilators leading to superstructure should be protected with ratproof metal screen over the cowl opening, particularly when access to vents may be had by nearby pipes or cables or when ledges within the duct are formed by the structure. If there are no structural ledges below cowl in the duct and if the duct leads only to a ratproof hold where cargo is frequently removed, screens are not indicated unless desired to prevent passengers throwing cigarette butts below into the ship interior.

39. *Blowers.*—Blower intakes must be protected with ratproof wire mesh to prevent access to the system of ventilating ducts (plate 28).

40. *Skylights.*—Screen metal skylights with tightly fitting wire mesh.

41. *Machinery foundations—motor bases.*—Design bases and foundations to eliminate closed spaces. Open-type structural-steel foundations are preferred (plates 18 and 19).

42. *Life-belt boxes.*—Design in metal with perforated plate over vent holes. Place flush on deck or elevate 10 to 12 inches above deck. If secured to deck-

head above, locate so top of box is not over three-eighths inch from deck plate and close all openings into box with metal. Locate overhead box well away from adjacent structural members (plates 12 and 30).

43. *Fire-hose lockers.*—Construct entirely of steel including a metal door, if used. Pipes entering this enclosure must fit snug in holes of recess partition or must have metal collars (plate 30).

44. *Switchboard enclosures.*—These are treated the same as item 43.

45. *Garbage containers.*—Portable garbage cans should be of steel, substantially constructed with tight-fitting covers and should be collapsible for storage when not in use (plate 20).

46. *Lifeboats.*—Eliminate all enclosed or hidden spaces by designing tanks integral with hull and laying thwarts directly on tank tops (plate 21).

47. *Rope reels for lifeboat falls.*—Boxes or drums carrying rope should be circular in shape and of steel construction, set up on legs 10 to 12 inches above deck. The center core should be a perforated-metal, hollow cylinder with openings only of ratproof dimensions. (See plate 30.)

48. *Electric refrigerators—water coolers.*—Screen in apertures at back and bottom. Place metal collars around pipes and cables passing through screens. Use only a tight-fitting door in front of machinery compartment.

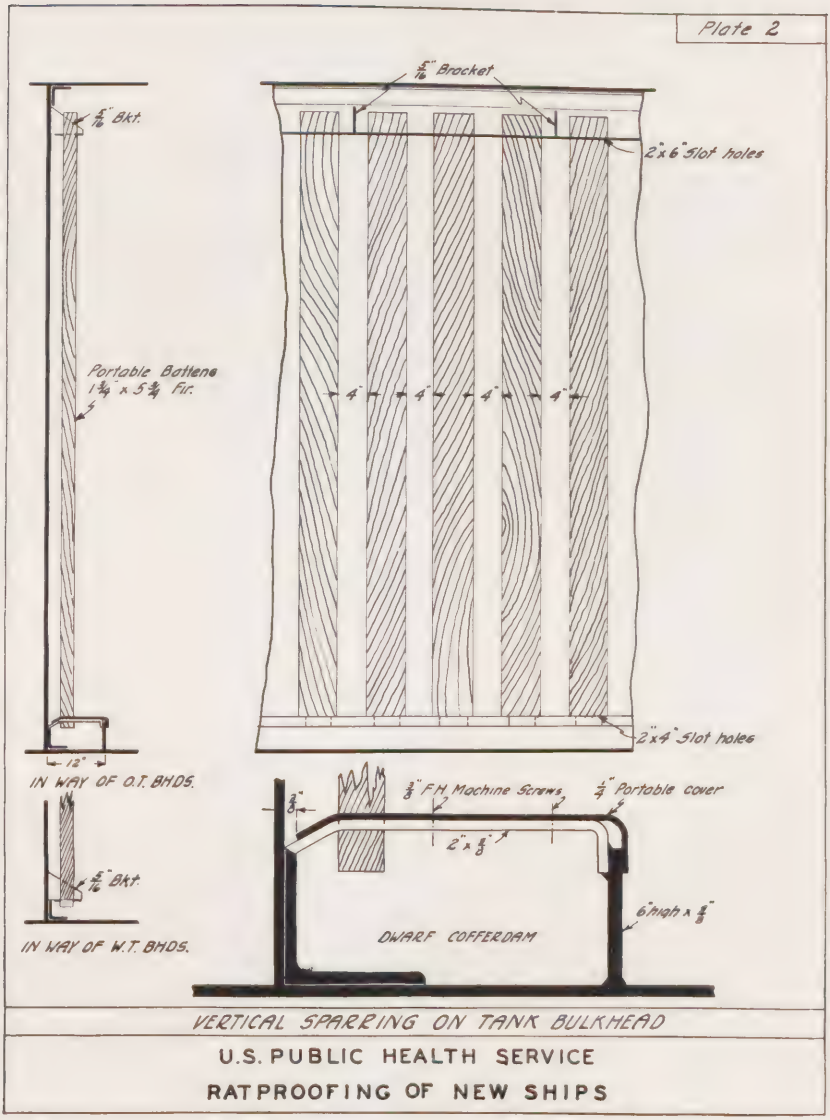
Plate 1

Note that longitudinals are fitted toe down. Also cargo battens are placed well above longitudinals and end brackets.

CARGO BATTENS

U.S. PUBLIC HEALTH SERVICE

RATPROOFING OF NEW SHIPS



VERTICAL SPARRING ON TANK BULKHEAD

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RATPROOFING OF NEW SHIPS

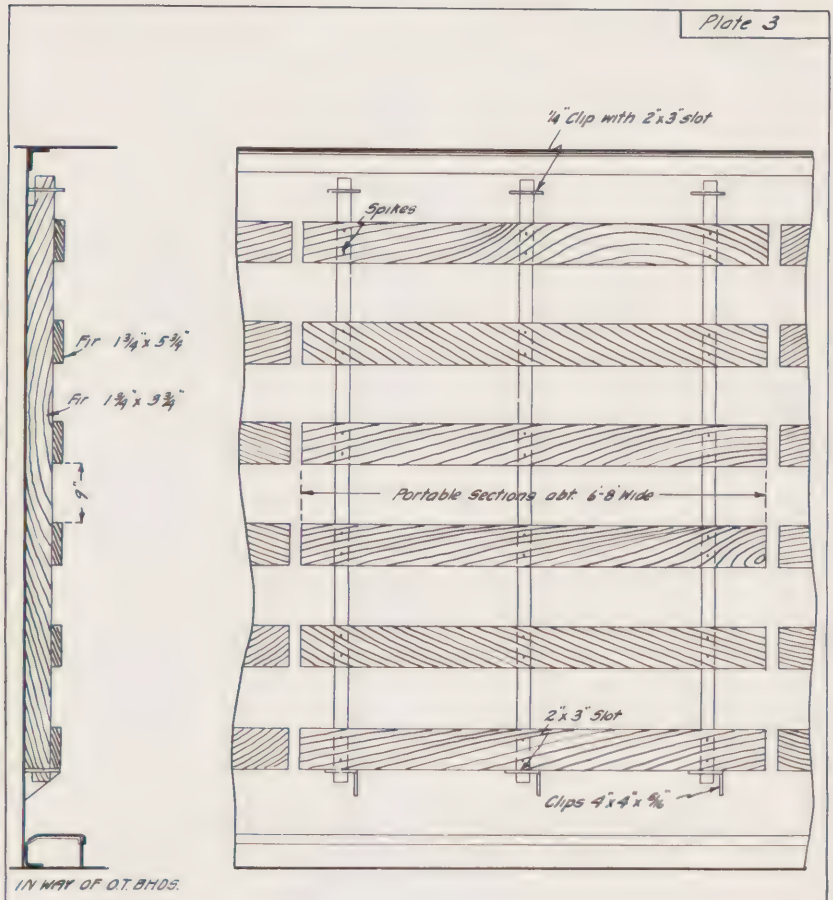


Plate 3
¼" Clip with 2"x3" slot
Spikes
Fir 1¾"x 5¾"
Fir 1¾"x 3¾"
9"
Portable Sections abt. 6'-8" wide
2"x 3" Slot
Clips 4"x4"x ⅝"
IN WAY OF O.T. BHDS.
Note.
For details of cofferdam see Plate 2
HORIZONTAL SPARRING ON TANK BULKHEAD
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

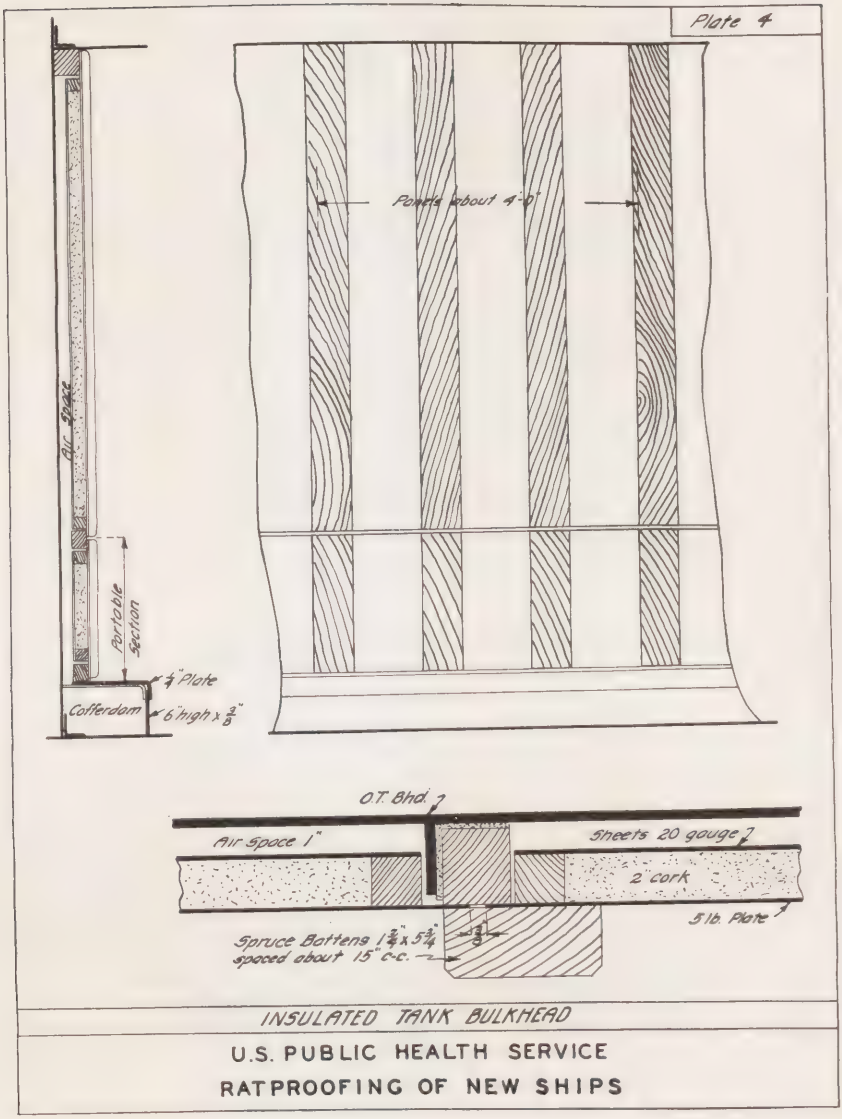
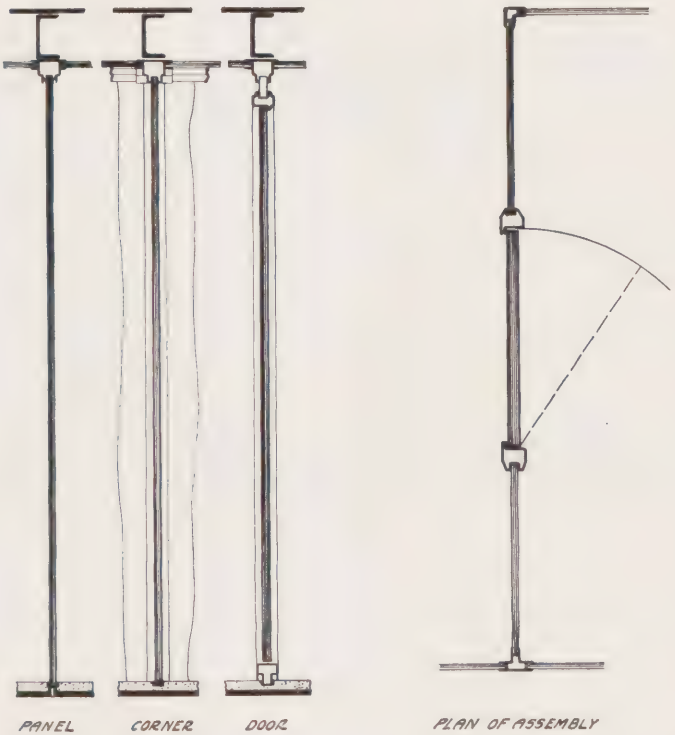


Plate 4
Panels about 4'-0"
Air Space
Portable Section
¼" Plate
Cofferdam
6" high x ⅜"
O.T. Bhd.
Air Space 1"
Sheets 20 gauge
2" cork
5/16 Plate
Spruce Battens 1¾" x 5¾"
spaced about 15" c-c.
⅜
INSULATED TANK BULKHEAD
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

Plate 5



Note bulkheads are metal covered and enclosed spaces are of tightly fitting metal

STATEROOM BULKHEADS

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RATPROOFING OF NEW SHIPS

132669°—39——4

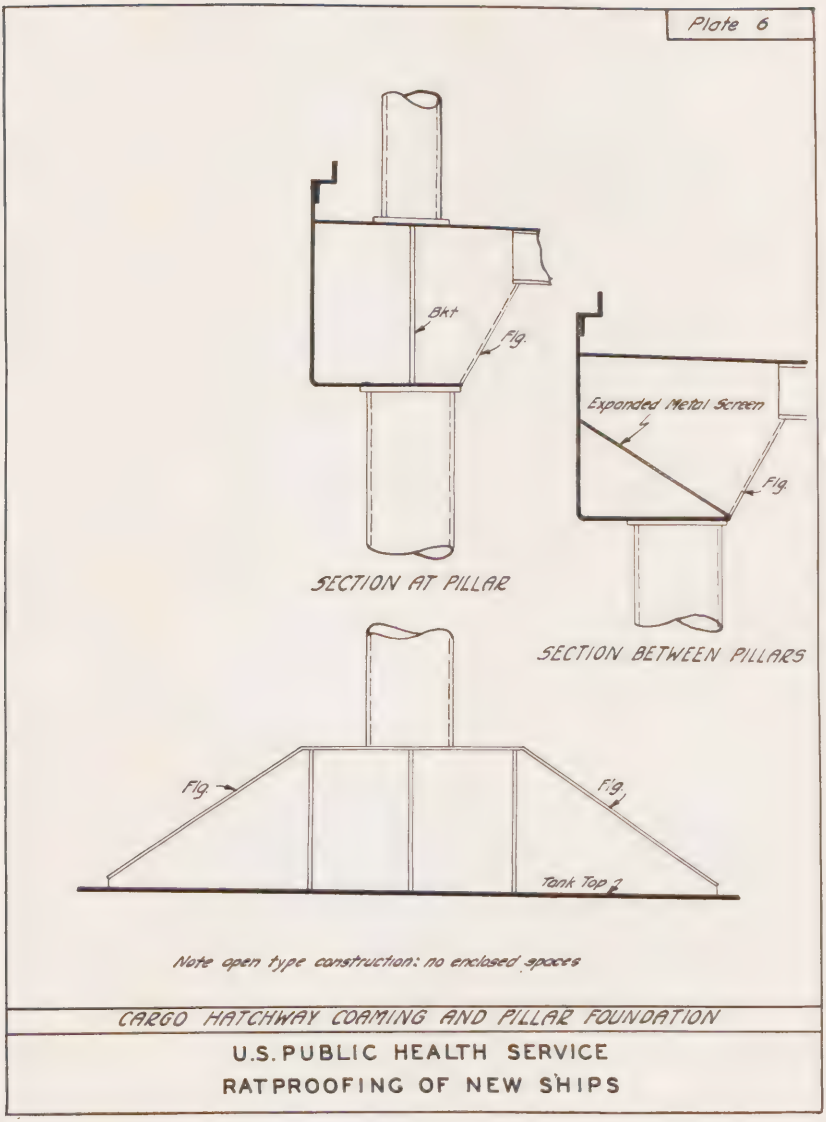


Plate 6
Bkt
Flg.
SECTION AT PILLAR
Expanded Metal Screen
Flg.
SECTION BETWEEN PILLARS
Flg.
Flg.
Tank Top
Note open type construction: no enclosed spaces
CARGO HATCHWAY COAMING AND PILLAR FOUNDATION
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

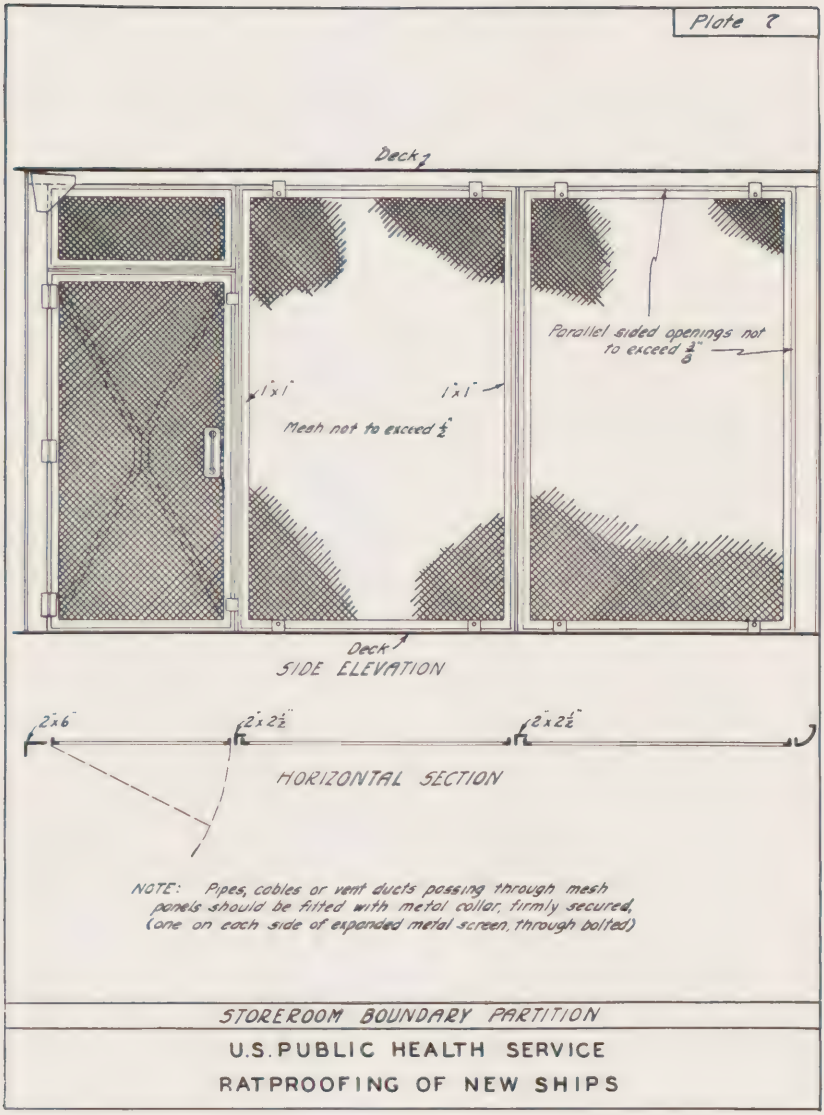


Plate 7
Deck
Parallel sided openings not to exceed 2/3"
1"x1"
1"x1"
Mesh not to exceed 1/2"
Deck
SIDE ELEVATION
2"x6"
2"x2½"
2"x2½"
HORIZONTAL SECTION
NOTE: Pipes, cables or vent ducts passing through mesh panels should be fitted with metal collar, firmly secured, (one on each side of expanded metal screen, through bolted)
STOREROOM BOUNDARY PARTITION
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

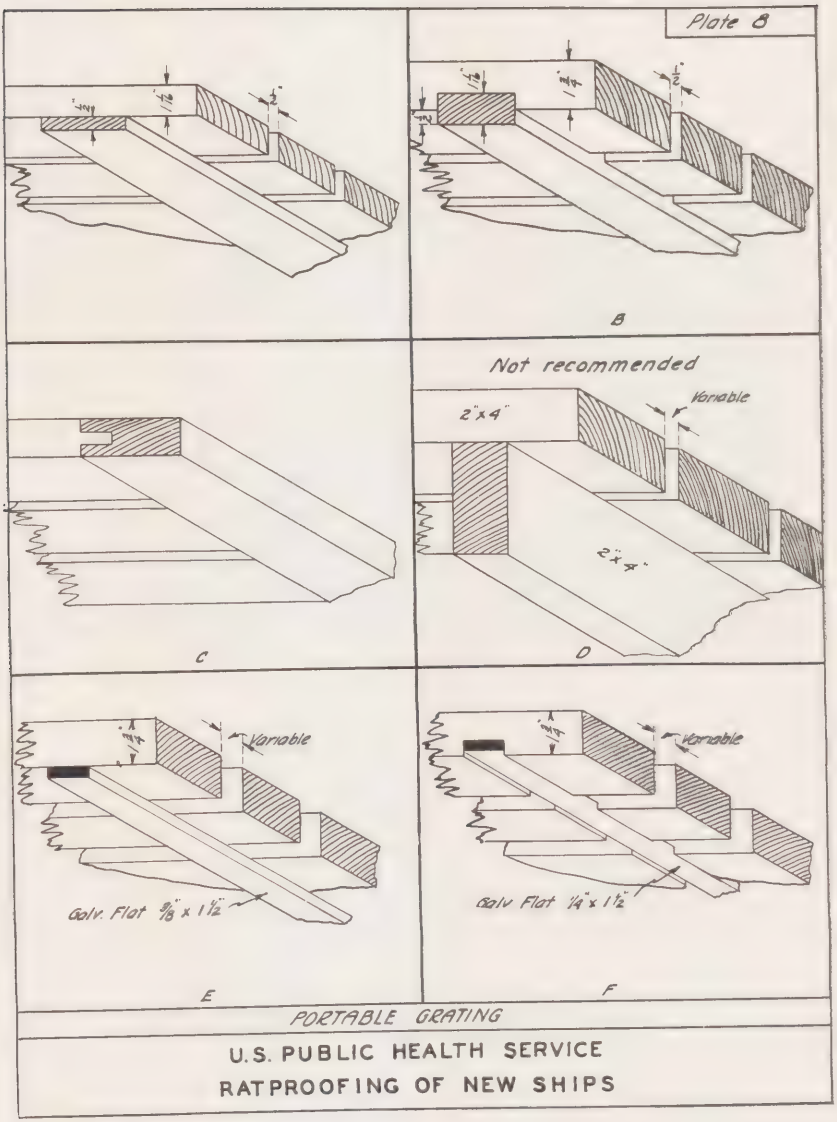


Plate 8
B
Not recommended
2"x4"
Variable
2"x4"
C
D
Variable
Galv. Flat 3/8" x 1 1/2"
Variable
Galv Flat 1/4" x 1 1/2"
E
F
PORTABLE GRATING
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

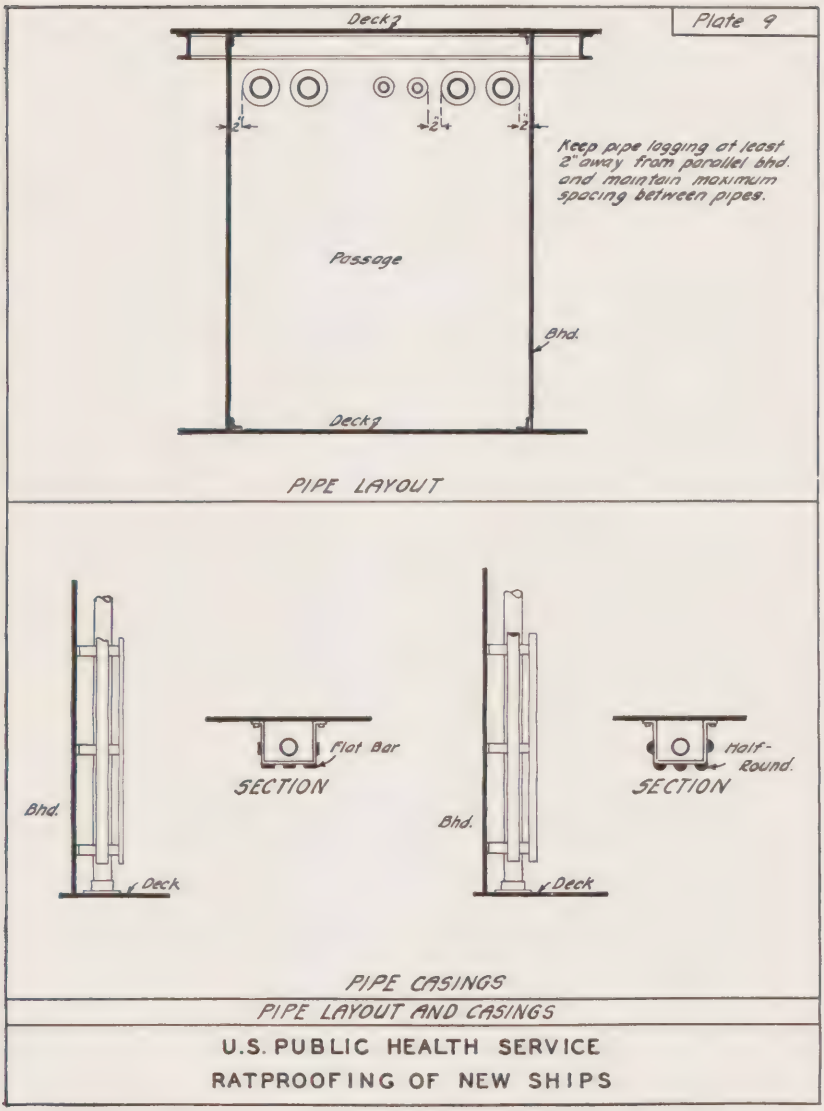


Plate 9
Deck
2"
2"
2"
Keep pipe lagging at least 2" away from parallel bhd. and maintain maximum spacing between pipes.
Passage
Bhd.
Deck
PIPE LAYOUT
Bhd.
Deck
Flat Bar
SECTION
Bhd.
Deck
Half-Round.
SECTION
PIPE CASINGS
PIPE LAYOUT AND CASINGS
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

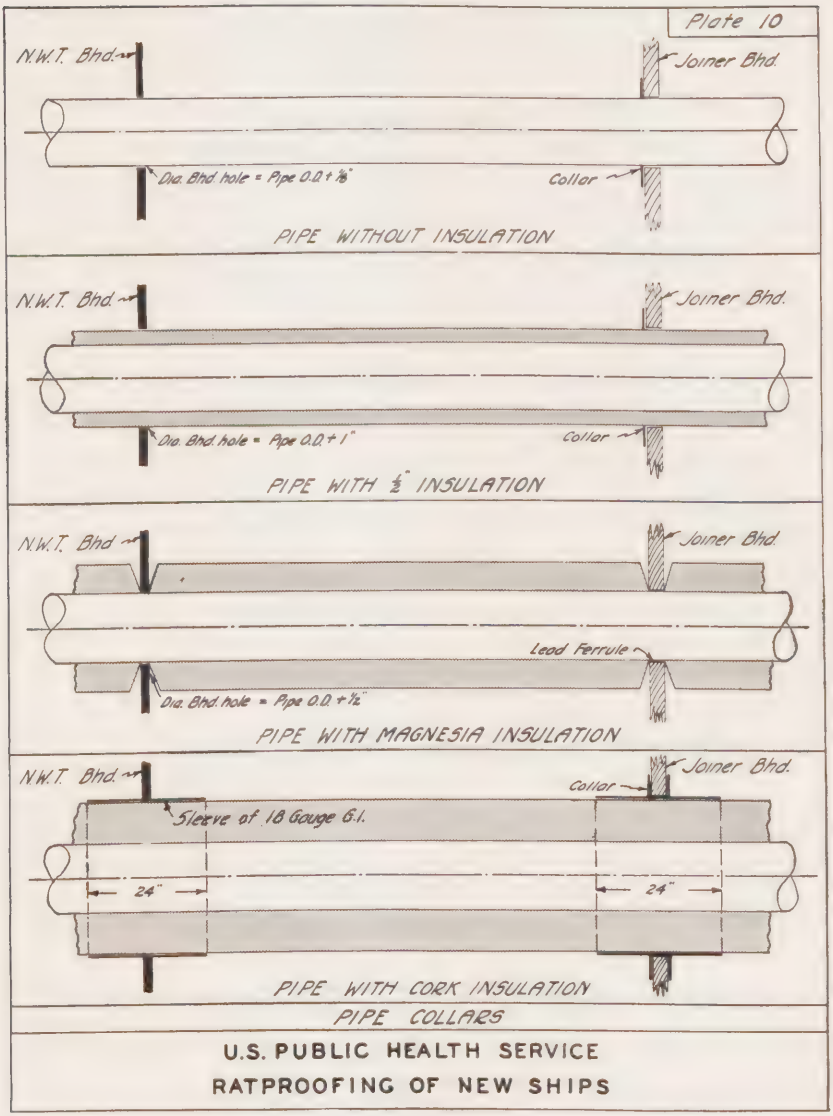
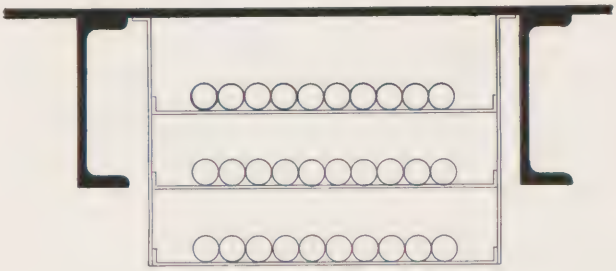


Plate 10
N.W.T. Bhd.
Joiner Bhd.
Dia. Bhd. hole = Pipe O.D. + 1/8"
Collar
PIPE WITHOUT INSULATION
N.W.T. Bhd.
Joiner Bhd.
Dia. Bhd. hole = Pipe O.D. + 1"
Collar
PIPE WITH 1/2" INSULATION
N.W.T. Bhd
Joiner Bhd.
Lead Ferrule
Dia. Bhd. hole = Pipe O.D. + 1/2"
PIPE WITH MAGNESIA INSULATION
N.W.T. Bhd.
Collar
Joiner Bhd.
Sleeve of 18 Gauge G.I.
24"
24"
PIPE WITH CORK INSULATION
PIPE COLLARS
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

Plate 11



Unsatisfactory Method

This type installation provides rat harborage. A large percent of the cables are inaccessible for repair, replacement or cleaning and painting.

Recommended Method

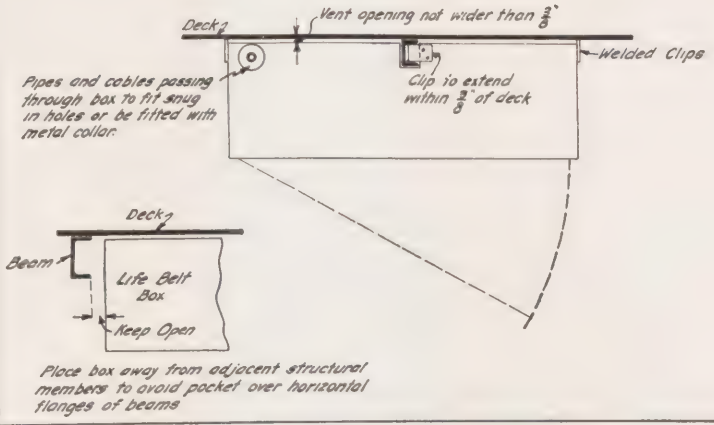
Multiple rows of electric cables vertically installed. This type installation eliminates ledge type harborage, is accessible for repairs and cleaning and does not materially reduce headroom.

ELECTRIC CABLE INSTALLATION

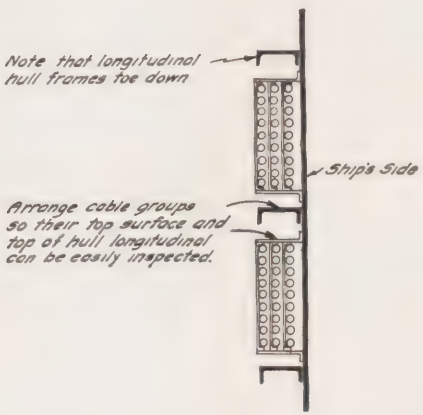
U.S. PUBLIC HEALTH SERVICE

RATPROOFING OF NEW SHIPS

Plate 12



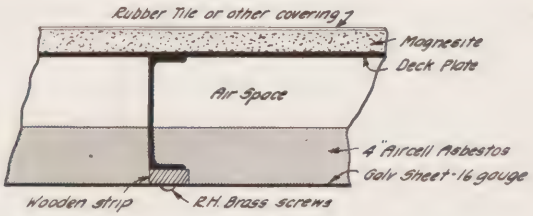
OVERHEAD LIFE BELT BOX



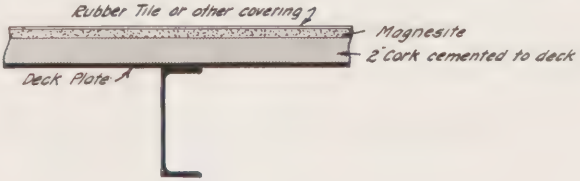
CABLES AT SHIP'S SIDE

U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

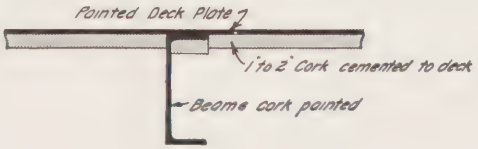
Plate 13



TYPE A



TYPE B



TYPE C

GALLEY DECKHEAD INSULATION

U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

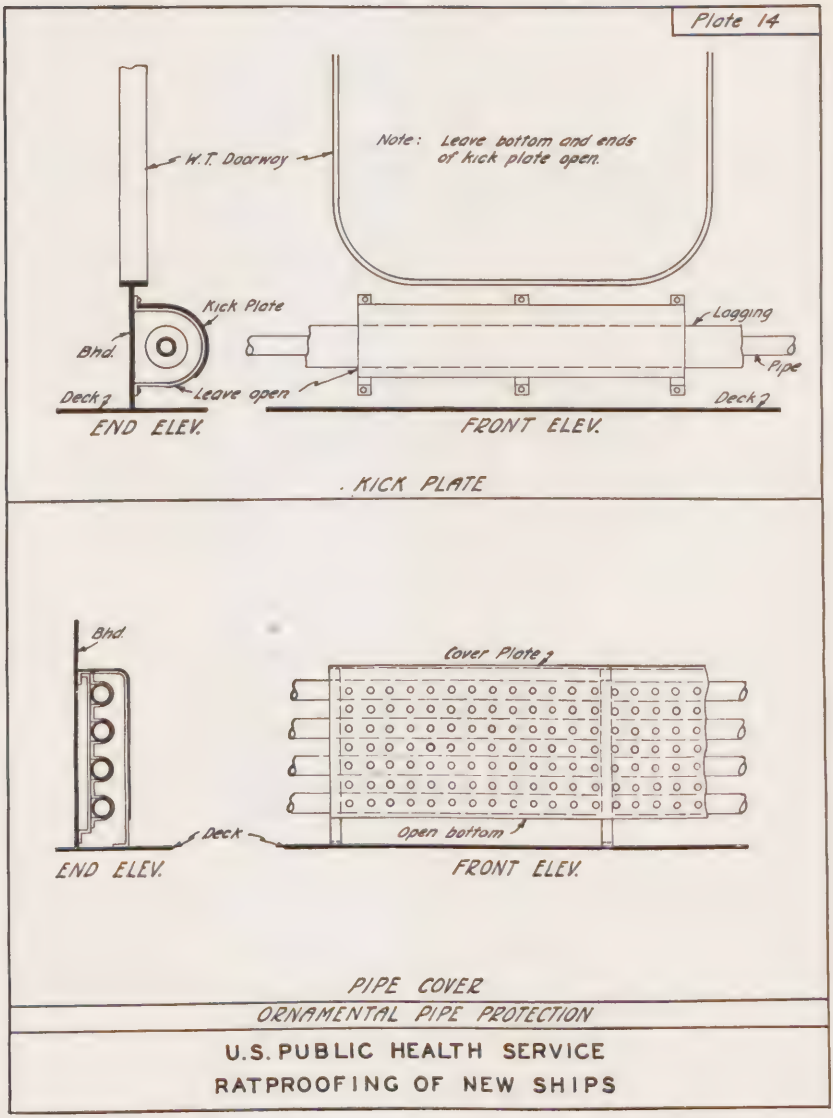
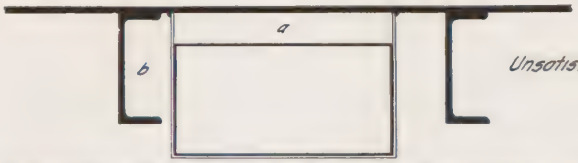


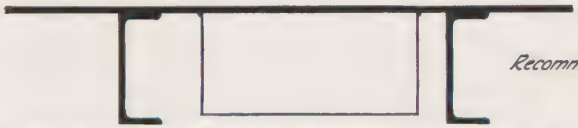
Plate 14
W.T. Doorway
Note: Leave bottom and ends of kick plate open.
Kick Plate
Bhd.
Deck
Leave open
Logging
Pipe
Deck
END ELEV.
FRONT ELEV.
KICK PLATE
Bhd.
Cover Plate
Deck
Open bottom
END ELEV.
FRONT ELEV.
PIPE COVER
ORNAMENTAL PIPE PROTECTION
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

Plate 15



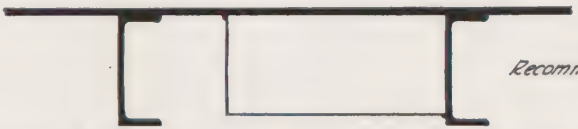
Unsatisfactory

This method of installation to be avoided as it forms rat harborage. Space "a" on top is inaccessible for inspection and cleaning. Space "b" is similarly inaccessible.



Recommended

Suggested method of installing rectangular vent ducts, eliminating rat harborage indicated in top sketch. Side of duct should be away from bosom of beam as indicated.



Recommended

Another method of installation which accomplishes the same purpose but is of less weight as the deck plate and deck beam form the top and one side of duct. Insulation of duct may be accomplished if desired.

Recommended

Another method of installation where headroom will permit. A duct constructed with circular top reduces incidence of harborage. This type permits easy inspection of top which offers practically no facilities for nesting.

VENTILATING TRUNKS

U.S. PUBLIC HEALTH SERVICE

RATPROOFING OF NEW SHIPS

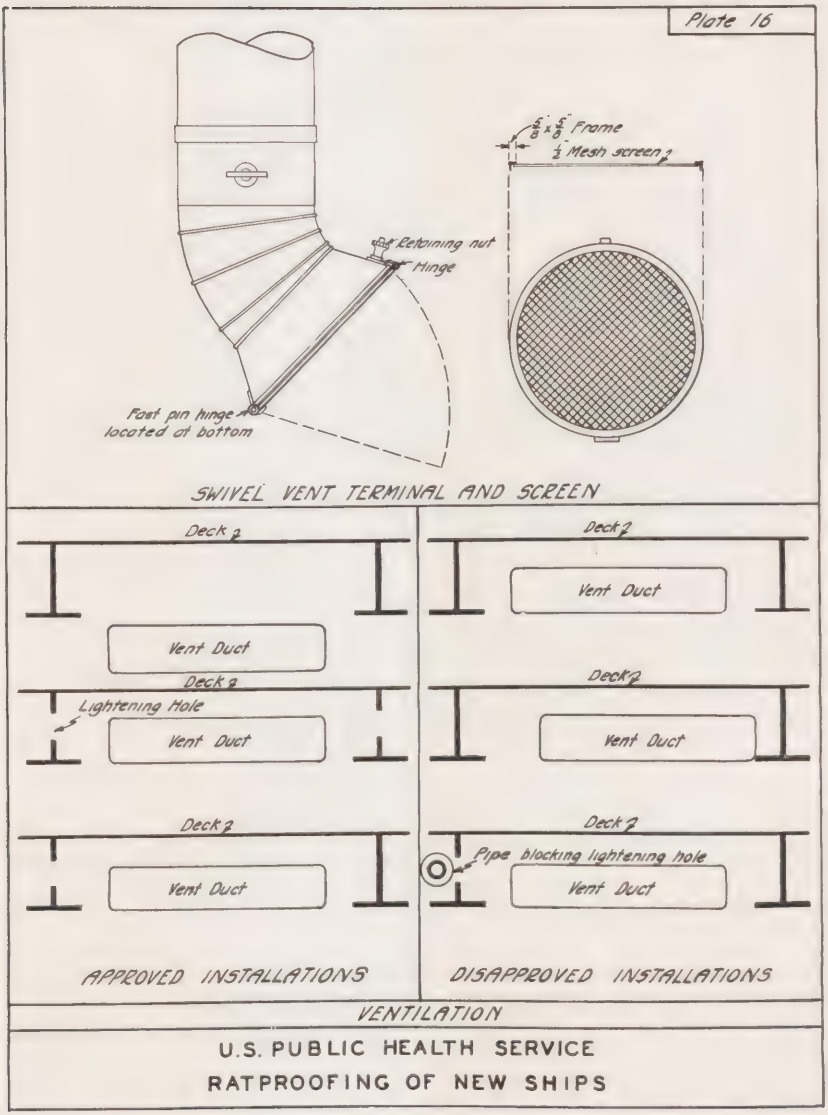
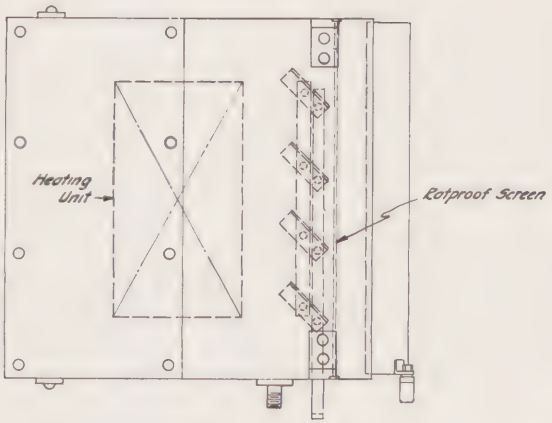
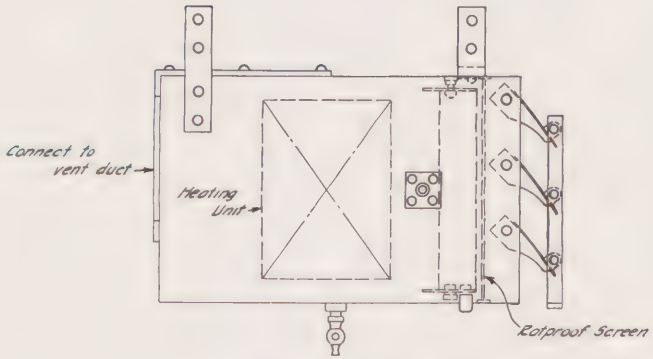


Plate 16
5/8 x 5/8 Frame
1/4 Mesh screen
Retaining nut
Hinge
Foot pin hinge located at bottom
SWIVEL VENT TERMINAL AND SCREEN
Deck
Vent Duct
Lightening Hole
Pipe blocking lightening hole
APPROVED INSTALLATIONS
DISAPPROVED INSTALLATIONS
VENTILATION
U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

Plate 17



PLAN



END ELEVATION

VENT TERMINAL HEATER

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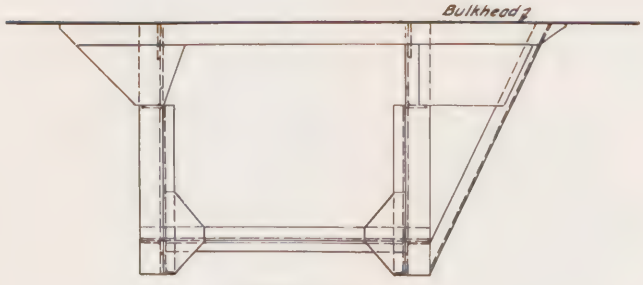
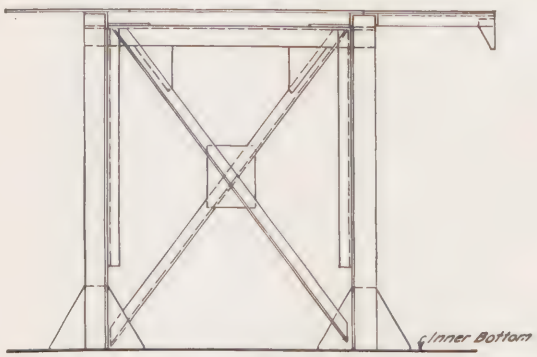
RATPROOFING OF NEW SHIPS

Plate 18



PLAN

Note open type construction: no enclosed spaces



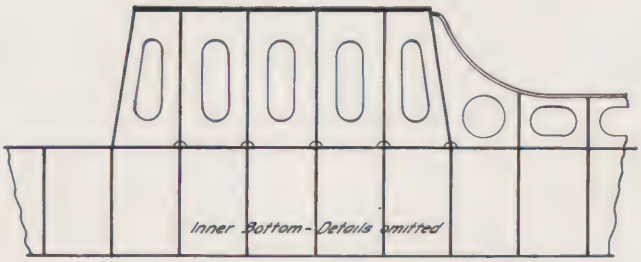
SIDE ELEVATION

FOUNDATION FOR AUX. CONDENSER

AUXILIARY FOUNDATIONS

U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

Plate 19



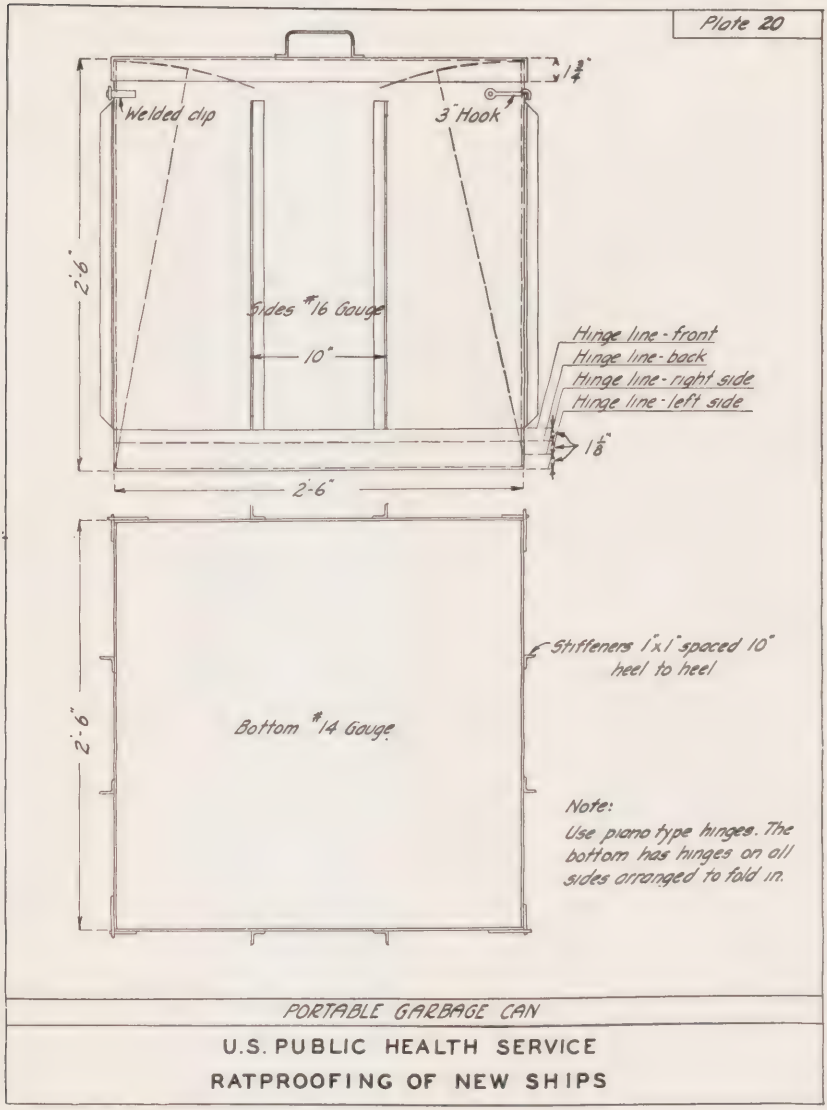
FORE AND AFT ELEVATION

TRANSVERSE GIRDER

Note open type construction: no enclosed spaces

MAIN MACHINERY FOUNDATION

U.S. PUBLIC HEALTH SERVICE
RATPROOFING OF NEW SHIPS

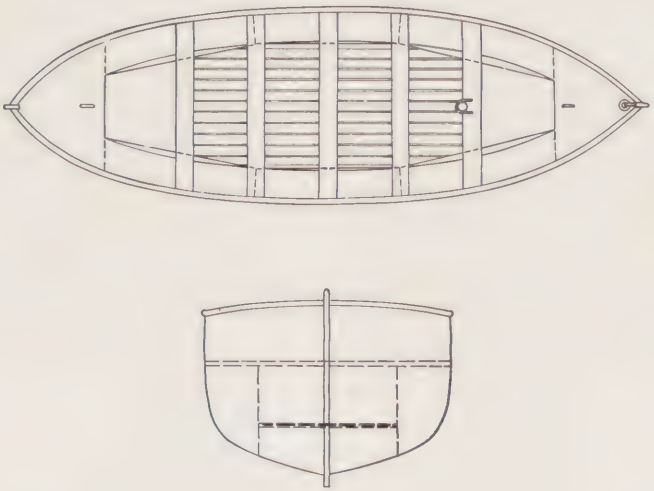


PORTABLE GARBAGE CAN

U.S. PUBLIC HEALTH SERVICE

RATPROOFING OF NEW SHIPS

Plate 21

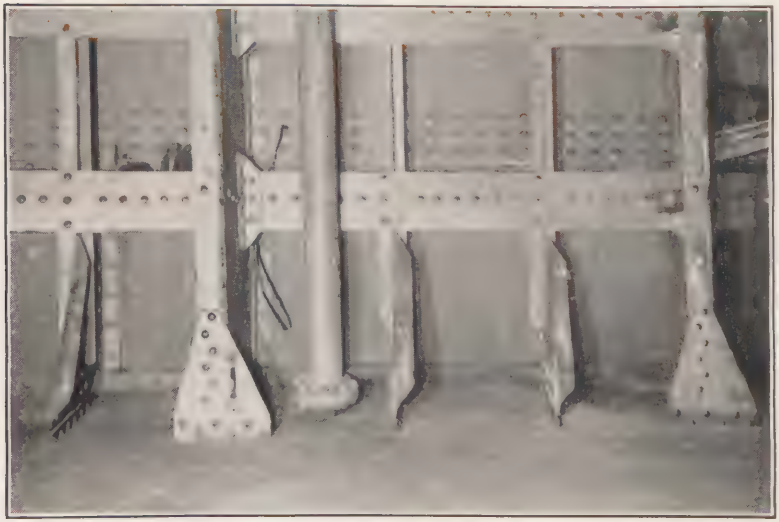


Note: Harborage on top behind and below air tanks is eliminated by this type of construction. Tanks are made integral with hull. The joint between plates of tank and hull are riveted and soldered the same as other hull joints. Thwarts are laid directly on tank top.

RATPROOF LIFEBOAT

U.S. PUBLIC HEALTH SERVICE

RATPROOFING OF NEW SHIPS

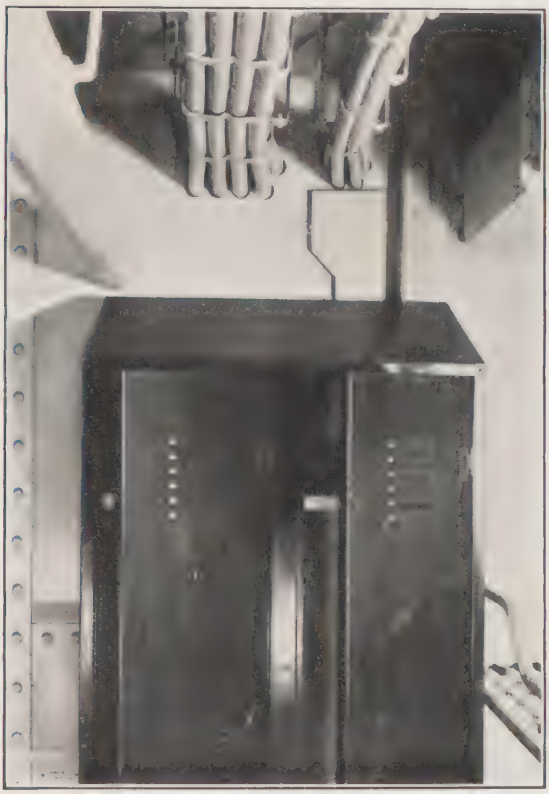


Bare tank top extended horizontally to ship's side.

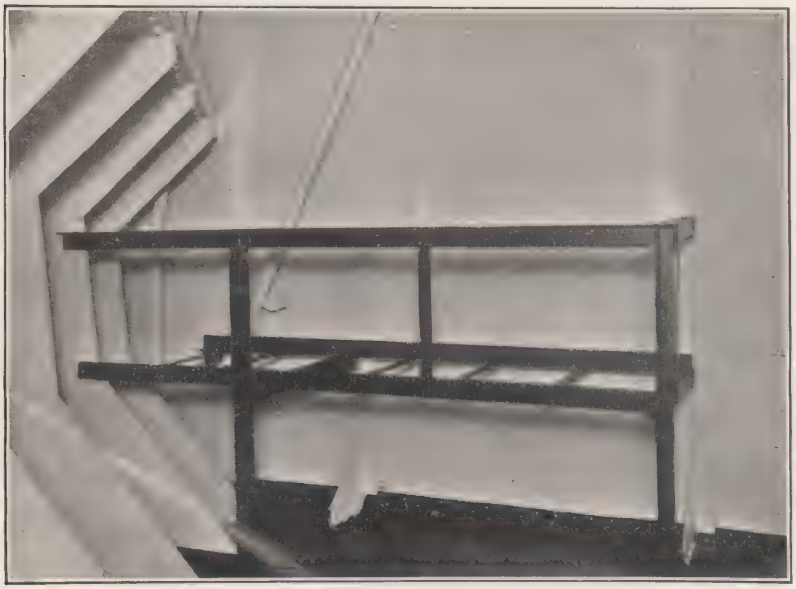
Ratproo fscreen to protect nonaccessible head of cargo hold pillar.

Chilled cargo space, showing necessary protection if partitions are made of wood.

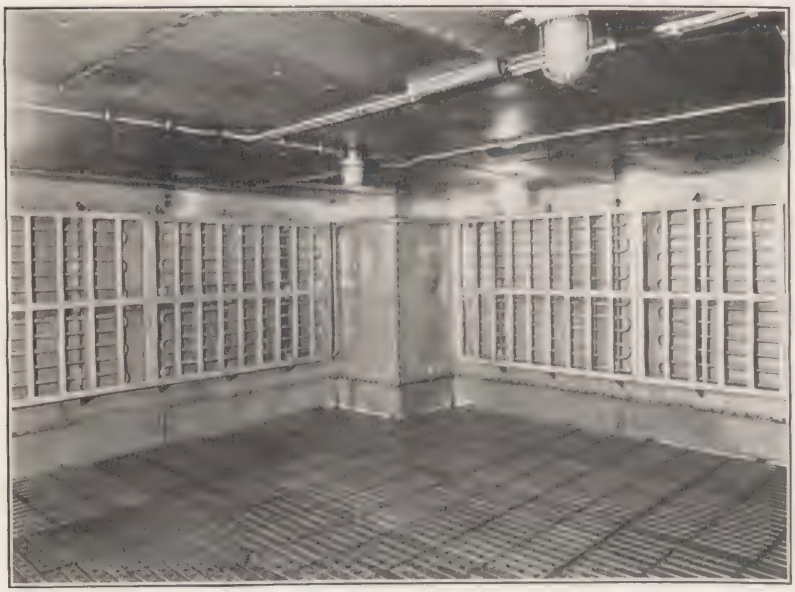
Ratproof mail room entirely of open type, metal construction.



Clothes locker with sloping top affords no harborage.



Excellent type of storage shelves made of welded structural steel.



Ideal refrigerator space entirely of metal construction which conforms to U. S. Navy practice.

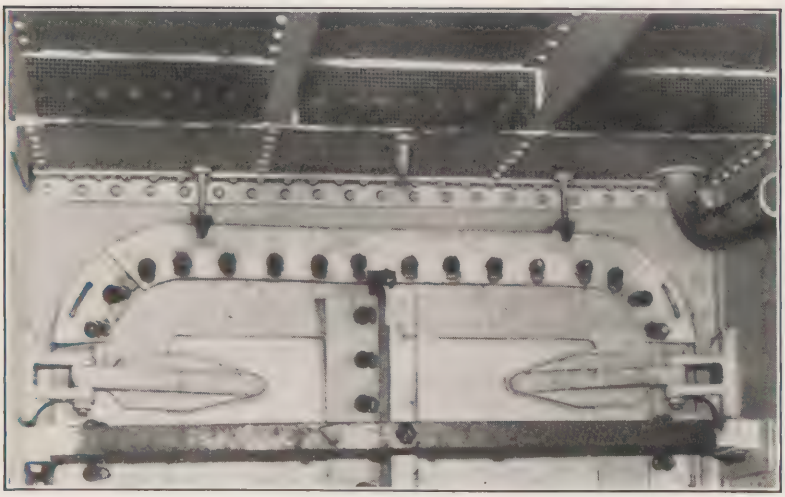
Ideal refrigerator space entirely of metal construction which conforms to U. S. Navy practice.

Shelves for storage of food. Note open type construction.

Excellent type of potato locker entirely of metal with no interior grating.

Expanded metal bulkhead around galley. Note close-fitting collar around pipe piercing the bulkhead.

Galley fixtures set up on legs off the deck, construction entirely open.



Stiffener shelf over cargo port must be entirely screened in; note pipe collar.

Public Health Reports, Supplement No. 151

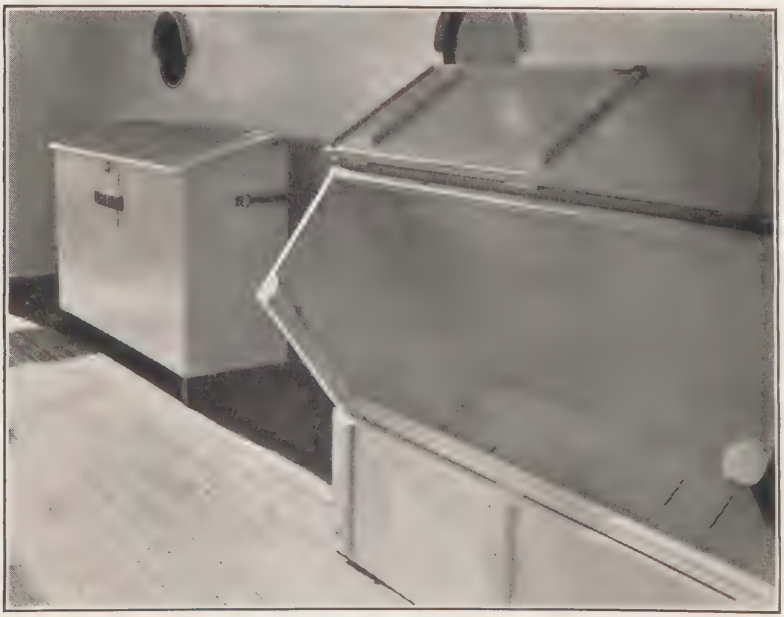
PLATE 28

Blower is protected by ratproof screen fitted inside the mushroom hood.

Ratproof steps. Note total absence of harborage.

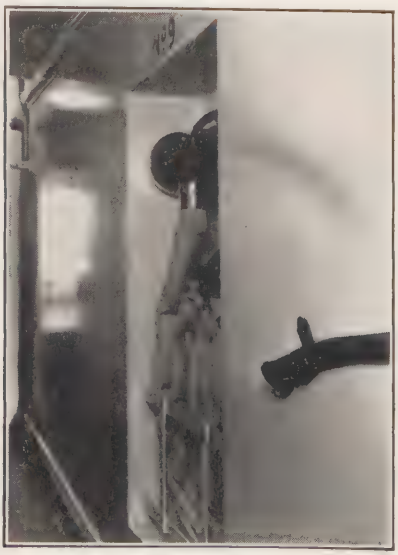
Excellent type of metal wardrobe with no false bottom. A curtain instead of the metal door is approved and recommended.

Public Health Reports, Supplement No. 151 PLATE 30



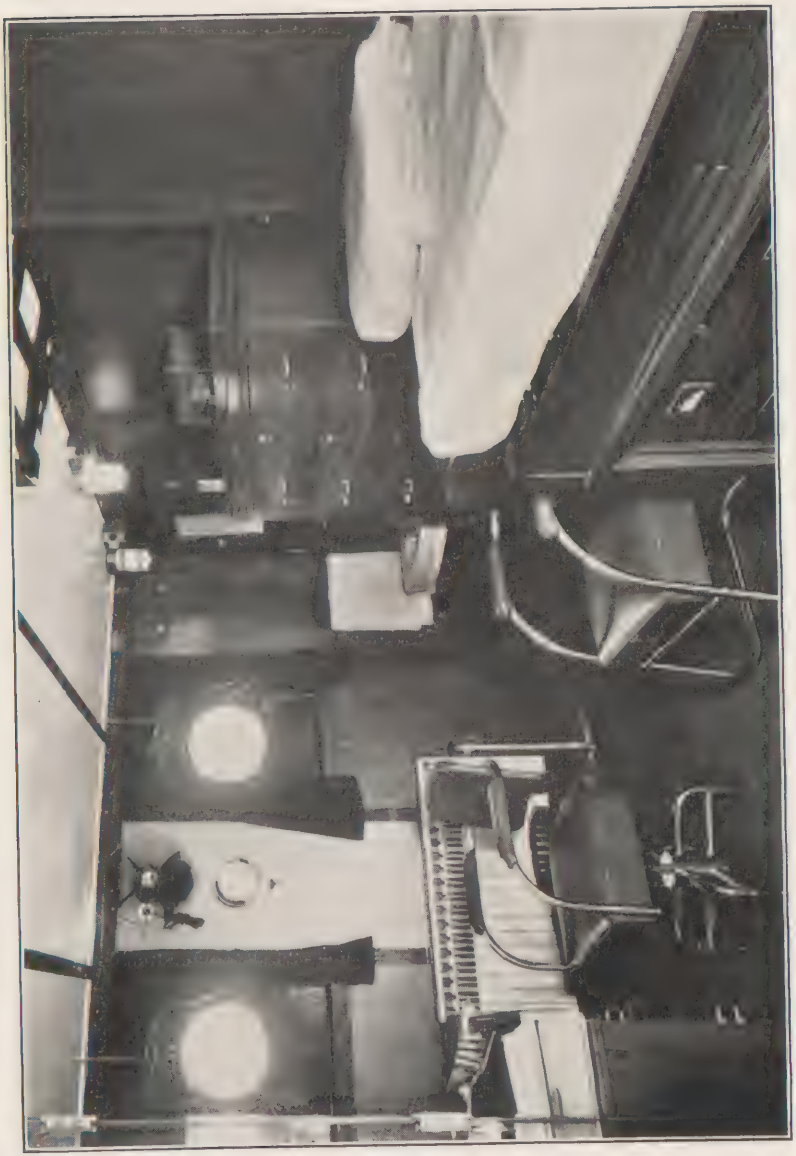
Wooden box for storage of life belts; note vent holes of ratproof dimensions and metal protection for gnawing edges.

Excellent rope reel with no harborage either in the reel or its foundation.



Excellent fire hydrant recess. Note all metal construction and that the recess is entirely open. If door is used make it of tight fitting metal.

PLATE 31



Recommended open type metal furniture.

Public Health Reports, Supplement No. 151

Recommended open type metal furniture.

INDEX